STAFF WORKING PAPERS

THE SCOPE OF THE HIGH-DEFINITION TELEVISION MARKET AND ITS IMPLICATIONS FOR COMPETITIVENESS

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PREFACE

This Congressional Budget Office (CBO) staff working paper analyzes major private forecasts of the market for high-definition television (HDTV). The study is an interim report, requested by the Senate Committee on Governmental Affairs, on work in progress in response to an earlier request from that Committee and the Senate Budget Committee. It analyzes the economic assumptions that underlie widely used forecasts of the HDTV market, and evaluates the implications and soundness of these forecasts. The final report will analyze the possible use of federal funds to support industry consortia, such as the one proposed for HDTV. In keeping with CBO's mandate to provide nonpartisan analysis, this report makes no recommendations.

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SUMMARY

Some analysts believe that high-definition television (HDTV) will be the next major successful consumer electronics product. At stake are both the market for HDTV products themselves and the markets for electronic inputs--in particular, semiconductors--and other associated electronic goods. The belief that HDTV will be a very important market has led to a wide range of proposals that federal agencies provide support for the development of HDTV capability among U.S. firms. This report analyzes three major private forecasts of the market for HDTV and asks two questions:

- Will there be a large market for HDTV sets? and
- Is this market critical to the competitiveness of the U.S. electronics sector?

The answer to the first question depends on many variables. The three market studies analyzed here seem to be at the high range of the industry's likely sales. The answer to the second seems clearer: even the most optimistic market growth would be unlikely to affect other electronics industries in the way suggested by proponents of HDTV. In reviewing the claims for HDTV made in the market forecasts, CBO found in general that either the markets were unlikely to be big enough to have the hoped for effects, or the sequences of events asserted by the studies were not sufficiently developed to warrant the conclusions drawn.

MARKET SIZE

No one can foresee how successful HDTV will be. The success predicted by private market forecasts may be justified by the large price differentials consumers have paid for color television over monochrome, and by the recent rapid growth of the premium television receiver market. Whether consumers will value the incremental benefits of HDTV as highly, however, is not clear, especially if there were intermediate types of advanced television to choose from. Evidence from consumer surveys suggest that viewers' preferences for HDTV vary with the program's subject matter, distance from the set, and other factors (including the picture quality of alternative standard TV sets).

The success of HDTV in the shorter term most likely will depend on how it is brought into the consumer marketplace and on other variables that the market studies have not addressed. As has been shown in product after product, consumers place emphasis on features usually unforeseen by the "experts." The introduction of high-technology consumer products is usually followed by a lengthy trial period in

which consumers, producers, and providers of ancillary services such as retailers grope toward a definition of the product. By contrast, the market forecasts reviewed in this report see HDTV as an instant success--an event that eluded some of today's most popular consumer electronics products, such as video cassette recorders (VCRs) and microwave ovens. Thus, some skepticism about the timing, if not the size, of HDTV's eventual market success seems warranted.

COMPETITIVENESS IN OTHER ELECTRONICS PRODUCTS

The likely effect of HDTV on other electronics markets seems clearer. If the HDTV market reaches a substantial size, most HDTV receivers would probably be produced in the United States regardless of whether foreign- or domestic-based manufacturers become the dominant suppliers, although the possible introduction of flat-panel televisions at the premium end of the market might reduce the U.S. manufactured content somewhat. Receivers are produced in the United States primarily because of the bulk and fragility of many of the components, particularly the television tube and the cabinet. However, even if domestic firms become the dominant suppliers, some components (semiconductors in particular) probably would be imported. U.S. firms dominate the personal computer market while buying many of their semiconductors from abroad.

Even the optimistic forecasts of the potential size of the HDTV market are small relative to the other markets in the electronics sector. Thus, it is unlikely that HDTV will play a pivotal role in the competitiveness and technology development of the sector as a whole. U.S.-based electronics manufacturing firms may gain or lose market share in the next 20 years, but they already have many incentives to maintain their competitiveness and a large enough market in which to enjoy economies of scale. Exactly how the HDTV market would change the competitiveness of U.S. producers on the whole is unclear. The entire world market for electronic equipment grew by $54 billion in 1988 to reach $461 billion. The world market for HDTV receivers and VCRs is forecast to be less than $30 billion (in 1988 dollars) by the year 2010. It seems counterintuitive to suggest that a small market that may exist in the future is a more important driver of economies of scale, technology, and competitive success than is the growth in the present market.

These conclusions do not necessarily mean that federal support for HDTV development is without merit. Support for HDTV might be justified for reasons other than competitiveness in the electronics sector--for instance, employment, national prestige, or scientific advancement. The Defense Advanced Research Projects Agency is pursuing HDTV-related technologies, primarily flat-panel display screens and digital imaging technology, for possible use in military applications. In addition, HDTV development, although small on its own, might also have a role to play in a broader strategy for government involvement in the U.S. electronics sector, including attempts to create a U.S. industry manufacturing the whole range of consumer electronics.

CHAPTER I

INTRODUCTION

Concerns about the competitiveness of U.S. industry have prompted Congressional proposals for additional federal support to increase the rate at which U.S. firms bring new technology to market. Proponents of such incentives argue that because federal agencies do not now provide much support for technologies that are near commercial development, certain U.S. industries are at a commercial disadvantage relative to industries in countries that provide such aid. The erosion of the international market share of several U.S. high-technology industries is interpreted as evidence of this problem.

One potential new product receiving a great deal of attention as a candidate for such incentives is high-definition television (HDTV)--a term referring to television receivers with new technology that will combine computers and conventional television technology (see Box 1). To provide truly enhanced television pictures, more information will have to be transmitted, stored, processed, and displayed on a screen. As a consequence, the components of these new sets may be closer to those of an engineering workstation or personal computer than to the current generation of television receivers. The components that have received the most attention include semiconductors--most notably, memory chips and digital signal processing devices--and flat-panel display screens.

Spurred in part by the recent success of foreign manufacturers of consumer electronic goods, such as the video cassette recorder (VCR) and the audio compact disk player, proponents of federal support for commercializing new technology argue that without a substantial U.S. presence in the market for HDTV receivers, U.S. electronics firms and related manufacturers will be handicapped relative to foreign firms, which will come to dominate these large markets. Thus, the competitive arena is the combined markets for HDTV receivers, the components for those receivers, and other electronic products that also use these components.

Supporters of federal assistance are concerned that U.S.-based manufacturers be among the initial suppliers of HDTV sets for the commercial market. The rationale offered for federal support is that the firms that initially gain a substantial portion of the HDTV market will subsequently be able to reduce their costs through economies of scale and associated learning curve advantages. Such cost reductions will give the initial market winners a competitive advantage not only in the HDTV market, but also in supplier and associated electronics markets (such as the semiconductor and personal computer markets).

Box 1

ADVANCED TELEVISION TECHNOLOGIES

The current debate over high-definition television (HDTV) has created a great deal of confusion over the meaning of commonly used terms. The studies discussed in this report each use terms common to the debate differently. Sometimes different terms refer to the same technology, while other times the same word refers to different technologies. The definitions of the technologies, as used in this report, are given below. They should not be considered precise definitions, partly because the technology and standards have not yet been set. Rather, these definitions can be viewed as "center of gravity" ideas, around which proposals for hardware standards are currently fluctuating.

The three new varieties of advanced television (ATV) that are usually discussed by engineers include: improved-definition (IDTV), enhanced- (or extended-) definition (EDTV), and high-definition. As the names suggest, each represents a successive generation of improved television technology. In this sense, they are like personal computers, where IBM-compatible personal computers were first developed with XT-compatible models, then with AT-compatible models, and most recently with 386-compatible models, each upwardly compatible with the same software. Under current Federal Communications Commission regulations, programs to be shown on ATV systems must be able to be viewed on receivers built for the current color television standard, also known as National Television Standards Committee (NTSC) technology. When programs are broadcast for ATV, however, viewers using NTSC receivers may not see as much as viewers watching on more advanced sets. This report focuses on high-definition television, not all forms of advanced television.

Improved-definition television. IDTV receivers have come on the market in 1989. This system requires no change in broadcast equipment or bandwidth, being mainly an improvement in receiver technology. In IDTV, the signal received is digitized, processed, stored in memory as a frame, and then displayed roughly 60 times per second. These receivers have a relatively small amount of memory (roughly 8 million bits) and other semiconductors for storage and digital signal processing. The screen looks like a conventional television screen.

Enhanced-definition television. EDTV receivers are expected in the U.S. market within the next half decade. The number of lines per television screen may be increased somewhat from the NTSC standard of 525 lines. In addition, the ratio of width to height of the television screen, currently 4 to 3, may be shifted to 15 or 16 to 9, making it closer to movie screen ratios. However, this would be accomplished within the current broadcasting bandwidth of 6 megahertz and by using much of the same broadcast equipment. The receivers would need more memory and digital signal processing than the IDTV to accommodate the same information, but would basically be a larger and faster version of the same device.

High-definition television. HDTV receivers would be introduced sometime after EDTV. They would be very similar to EDTV and IDTV, but the number of lines would be double the current U.S. standard, or between 1,050 and 1,260. They would have a movie screen-like ratio of width to height and digital-quality sound. Consequently, each frame would have roughly four times the information of the current television screen. For this reason, it would need roughly four times the memory of IDTV (or roughly 4 million bytes, or 32 million bits, of memory) and correspondingly more digital signal processing. In addition, HDTV would require new production and broadcast equipment as well as a greater allocation of the broadcast spectrum.

The desire for U.S.-based firms to have a substantial share of the HDTV market has produced a whole range of policy proposals. At one end, the Defense Advanced Research Projects Agency (DARPA) already has allocated $30 million over the next three years for research into technologies that relate to the HDTV display, primarily flat-panel screens, with potential military use. At the other end, the American Electronics Association (AEA) has proposed a package of federal support for HDTV that would include $1.0 billion in loans and loan guarantees for manufacturing facilities, $300 million over three years to expand DARPA's HDTV research, and $50 million to develop standards.[1]

These proposals reflect the divergence of views regarding HDTV. A more narrow definition of HDTV equates it with advanced-technology television receivers. A more expansive definition of HDTV, however, refers to the development and widespread use of low-cost, high-resolution digital techniques to create images for uses in medicine, scientific instruments, computing, and consumer products. In this broader definition, the consumer uses are not necessarily either the first or the most likely use to find a mass market.

The policy prescriptions following this divergence of views also differ. The narrower view of HDTV centers on the success of U.S.-based firms in manufacturing and selling television receivers. Consequently, the bulk of the federal financial support in the AEA proposal is devoted to manufacturing. By contrast, the DARPA request would develop generic technologies that would find widespread use in imaging products.

Both proposals share a common belief that, rather than compete directly with foreign electronics firms, U.S. electronics firms should preempt them by creating newer and better products, including consumer electronic products, and so increase the share of world electronics markets held by U.S.-based firms. In both proposals, HDTV--however defined--has a role to play in this creation of and expansion into new markets.

Most advocates of HDTV development view this one technology policy as part of a broader, though not entirely articulated, policy of support for the U.S. electronics sector that the federal government must undertake in order to restore that sector to full competitiveness. Not all programs are new: some, like Sematech, a semiconductor research and development (R&D) consortium, are already under way; in other instances, the goal is to reorder spending priorities within existing technology development programs. Although there is no agreement on the particular constellation of programs, most advocates feel that if the federal government pursues only HDTV and disregards other electronics markets, the position of U.S. firms will not be enhanced. On the other hand, if the government supports the full menu of programs, federal support of HDTV may contribute only marginally to the competitiveness of the U.S. electronics sector as a whole.

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1. American Electronics Association, "Background Information: Development of a U.S.-Based ATV Industry" (Santa Clara, Calif., May 9, 1989).

Part of the debate over federal participation in the development of HDTV focuses on the size of the market for HDTV sets and the importance of this market to the competitiveness of other U.S. electronics industries. Other aspects of the policy debate, including employment, scientific potential, national prestige, and possible federal uses of HDTV-related technologies, are also likely to weigh in the Congress' consideration. In this report, however, the Congressional Budget Office (CBO) focuses on the narrower issues of HDTV's market size and contribution to competitiveness and on the major HDTV market forecasts, assessing their potential economic implications and the validity of their assumptions and conclusions. The broader question of whether the public benefits from HDTV are sufficient to warrant a federal role is not addressed in this report.[2]

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2. This issue is taken up in the forthcoming CBO report, Federal Support for R&D Consortia.

CHAPTER II

THE MAJOR MARKET FORECASTS

Discussions of U.S. policy toward high-definition television focus on three market forecasts of HDTV sales. All predict that HDTV receivers will be available to consumers in the early 1990s and that programming for HDTV will begin shortly thereafter. The following summarizes the three market forecasts:

- The National Telecommunications and Information Administration (NTIA) commissioned a report, commonly known as the Darby report, which examines the growth patterns in sales of previous consumer electronic products and forecasts the growth of HDTV.[3] The Darby report differs from the others in that it has both low-growth and high-growth scenarios. It forecasts sales of HDTV receivers and video cassette recorders (VCRs) for the years 1997 through 2008. It concludes that if HDTV replicates the growth pattern of color televisions and VCRs, the market could expand rapidly to achieve annual sales of 18.6 million units by the year 2008.

- The Electronic Industries Association (EIA), a trade association that represents all electronics companies in the United States (whether foreign- or U.S.-based), commissioned a study of the HDTV market. That study predicts how the projected demand for HDTV will affect U.S. employment and overall economic activity.[4] Unlike the other two reports, the EIA forecast, which covers the period 1989 through 2003, excludes VCRs for HDTV. The EIA report concludes that sales of HDTV could reach 13.1 million units by 2003, raising income and employment in the electronics sector, regardless of whether the market is supplied by foreign- or domestic-based producers.

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3. Department of Commerce, National Telecommunications and Information Administration, "Economic Potential of Advanced Television Products" (prepared for NTIA by Darby Associates, Washington, D.C., April 7, 1988), referred to hereafter as the Darby report. Even though the report discusses all advanced television products and makes no distinctions in the text, the author has told CBO that the scenarios are for HDTV.

4. Electronic Industries Association, "Television Manufacturing in the United States: Economic Contributions--Past, Present, and Future" (produced under contract by Robert R. Nathan Associates, Washington, D.C., February 1989), referred to hereafter as the EIA report.

- The American Electronics Association (AEA), a trade association--which, in the area of HDTV, represents U.S.-based firms--is mainly concerned with how demand for HDTV could affect the competitiveness of U.S. high-technology industries.[5] The AEA forecast for both HDTV receivers and VCRs (and affiliated industries) covers the period 1990 through 2010. The AEA report forecasts sales of 11 million units by 2010 and concludes that unless 50 percent of the U.S. HDTV market is supplied by U.S.-based firms, the market shares of U.S. producers in other industries, most notably semiconductors and personal computers, will decline substantially.

One problem with any analysis of competitiveness is the definition of the nationality of firms and the products they make. Most analyses characterize the nationality of a firm by the nationality of its stockholders. This definition, however, ignores two important criteria: where production and where research and development (R&D) occur. It is not clear why a product made in Mexico by a firm owned by U.S. citizens is a U.S. product, while a product made in the United States by a firm owned by foreigners is a foreign product. R&D presents an equally vexing problem: while U.S. policymakers might want all firms to perform their R&D in the United States, many U.S.-based firms find it advantageous to perform their R&D in Japan or Europe. While recognizing these limitations, this report defines U.S.-based firms as firms owned by U.S. citizens, while foreign-based firms have foreign ownership.

SUMMARY AND COMPARISON OF THE MARKET FORECASTS

This section compares the forecasts in terms of annual unit sales, market value, and prices. Most data in the reports were presented in annual terms, but some data were given as cumulative figures. To facilitate analysis and comparison, CBO converted the cumulative data into yearly data. For example, a forecast of a market totaling $150 billion over the next 15 to 20 years will appear in this report as annual sales figures.

Unit Sales

The forecasts provide a range of market size and timing. Figure 1 compares the unit sales forecasts of the three reports. Darby's high-growth and the EIA forecasts see the market for HDTV sets becoming as large within the next 15 years as the market for color television sets was in the early 1980s (over 10 million units per year). EIA and AEA both see a market for HDTV as large as the current market for VCRs (11 million to 13 million units per year) within the next 15 to 20 years, with EIA being much more sanguine about HDTV's market growth.

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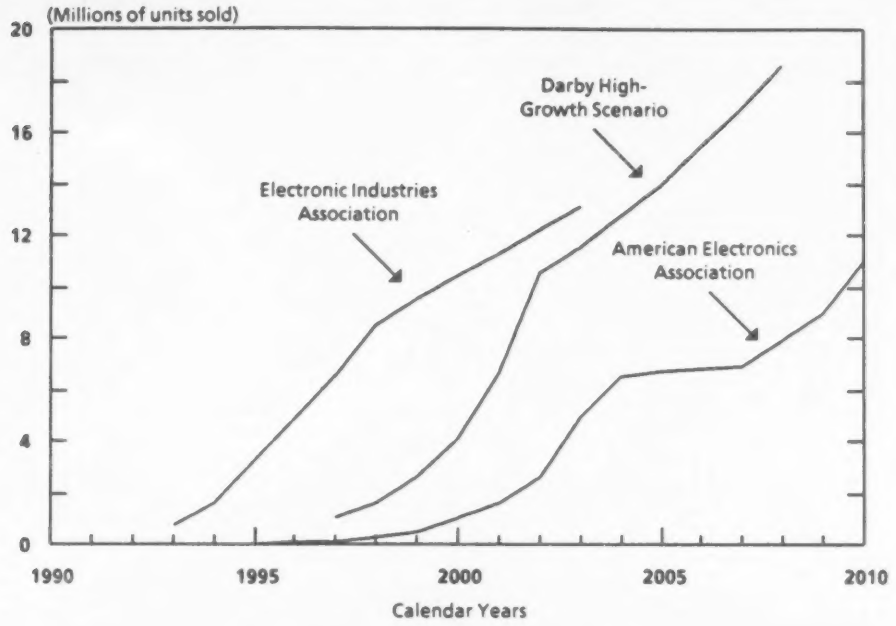
5. American Electronics Association, "High Definition Television (HDTV): Economic Analysis of Impact" (prepared by the ATV Task Force Economic Impact Team of the AEA, Santa Clara, Calif., November 1988), referred to hereafter as the AEA report. The report also presents forecasts for the world HDTV market. CBO did not analyze that portion of the AEA forecast.

Figure 1.
Projected Annual U.S. Unit Sales of High-Definition Television Receivers



SOURCES: Congressional Budget Office based on data from the Electronic Industries Association, "Television Manufacturing in the United States: Economic Contributions--Past, Present, and Future" (produced under contract by Robert R. Nathan Associates, Washington, D.C., February 1989); Department of Commerce, National Telecommunications and Information Administration, "Economic Potential of Advanced Television Products" (prepared for NTIA by Darby Associates, April 7, 1988), referred to as the Darby report; American Electronics Association, "High Definition Television (HDTV): Economic Analysis of Impact" (prepared by the ATV Task Force Economic Impact Team of the AEA, Santa Clara, Calif., November 1988).

NOTE: The unit sales in the Darby low-growth scenario (not shown) are less than 150,000 per year.

Since color television and VCRs have been among the most successful consumer items introduced over the last several decades, these forecasts of HDTV sales are probably near the high end of the potential range of market size. By contrast, Darby's low-growth scenario illustrates what would happen if HDTV ended up serving only a specialized (or niche) market, such as that which projection television--which is most commonly found in commercial establishments rather than in private homes--serves today.[6] In this scenario, HDTV receiver sales would remain at the 100,000 to 150,000 unit level, less than half the current sales of projection television.

Market Value

All forecasts but Darby's low-growth scenario suggest that the market value of HDTV sales will grow rapidly. Figure 2 presents the sales forecasts of the three reports in 1988 dollars. The data include the sales of HDTV receivers and HDTV-related VCRs, except for the EIA forecast which excludes VCRs. Darby's high-growth scenario rises almost continously; the others show markets that would peak at about the size of the current U.S. market for VCRs and television sets, which totaled about $11.5 billion in 1987.[7] The AEA forecast for HDTV and associated VCRs is $10.9 billion in the year 2010; the Darby high-growth scenario is $16.2 billion in 2008.[8] The EIA's forecast of $11.7 billion in 2003 for HDTV receivers, but not VCRs, is comparatively high next to the AEA forecast and Darby's high-growth scenario for both receivers and VCRs.[9] By contrast, the Darby low-growth forecast suggests a modest market of less than $600 million in 2008.

Receiver Price

Underlying these forecasts of market value and unit sales are very different assumptions about the pattern of price and cost reductions. Figure 3 shows the price assumptions for each study. Darby assumes that to achieve a high rate of market growth, the prices of HDTV receivers would have to be only a few hundred dollars more than current sets. In the Darby low-growth scenario, HDTV receiver prices remain at about $2,500. By contrast, both AEA and EIA have HDTV enjoying

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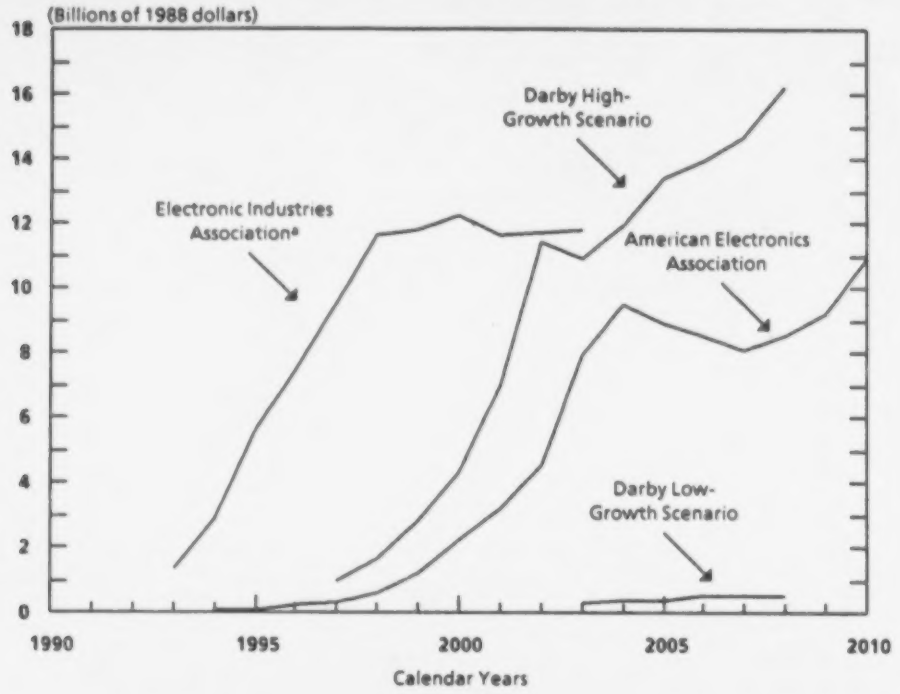
6. See the Darby report, p. 32. In contrast with the high-growth scenario, the low-growth scenario is undeveloped and had to be reconstructed by CBO. The Darby report states the low-growth scenario is an illustration of a possible range of sales rather than an actual forecast.

7. Electronic Industries Association, Electronic Market Data Book, 1988 (Washington, D.C: 1988), pp. 18 and 22.

8. The Darby report has two value trajectories for the high-growth scenario. CBO used the mean of the two.

9. CBO deflated the EIA value forecasts using EIA's projected average inflation of 3.5 percent per year.

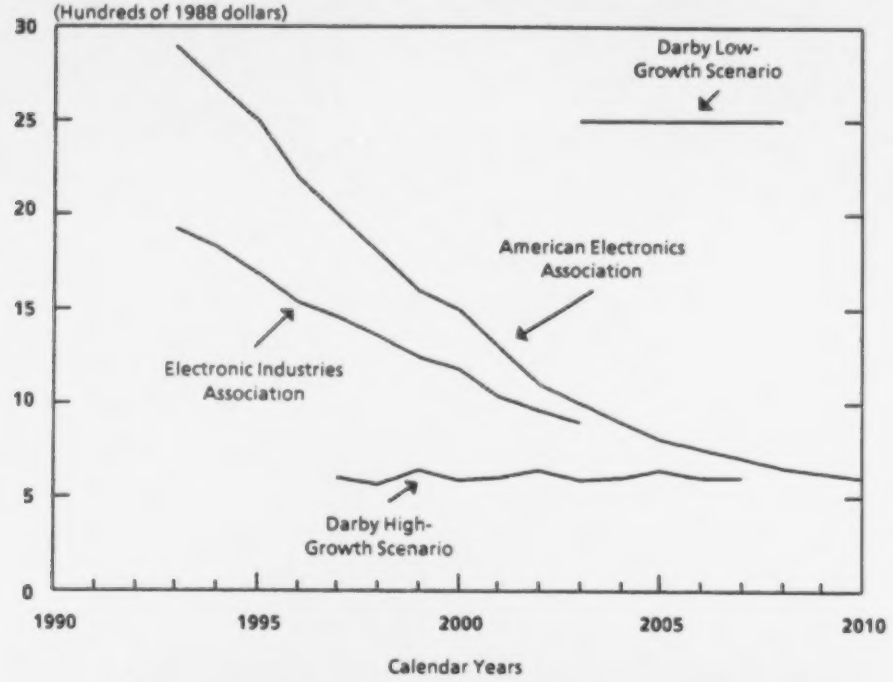
Figure 2.
Projected Annual U.S. Market Value of High-Definition Television Receivers and Related Video Cassette Recorders



SOURCES: Congressional Budget Office based on data from the Electronic Industries Association, "Television Manufacturing in the United States: Economic Contributions--Past, Present, and Future" (produced under contract by Robert R. Nathan Associates, Washington, D.C., February 1989); Department of Commerce, National Telecommunications and Information Administration, "Economic Potential of Advanced Television Products" (prepared for NTIA by Darby Associates, April 7, 1988), referred to as the Darby report; American Electronics Association, "High Definition Television (HDTV): Economic Analysis of Impact" (prepared by the ATV Task Force Economic Impact Team of the AEA, Santa Clara, Calif., November 1988).

a. Excludes VCRs.

Figure 3.
Projected Price of High-Definition Television Receivers



SOURCES: Congressional Budget Office based on data from the Electronic Industries Association, "Television Manufacturing in the United States: Economic Contributions--Past, Present, and Future" (produced under contract by Robert R. Nathan Associates, Washington, D.C., February 1989); Department of Commerce, National Telecommunications and Information Administration, "Economic Potential of Advanced Television Products" (prepared for NTIA by Darby Associates, April 7, 1988), referred to as the Darby report; American Electronics Association, "High Definition Television (HDTV): Economic Analysis of Impact" (prepared by the ATV Task Force Economic Impact Team of the AEA, Santa Clara, Calif., November 1988).

a multimillion unit market with prices well above $1,000, almost triple the current average price of a standard color TV set ($350) and a multiple of the projected value of improved-definition television--an intermediate technology closer to standard color television sets (see Box 1). The EIA and AEA forecasts of market growth would be roughly consistent with the history of color television: in the mid-1960s, the yearly demand for color television sets grew from 700,000 units to 5 million units while color television prices were roughly constant at $1,300 in 1988 dollars.[10] At that time, the differential between monochrome receivers and color receivers was $840 (in 1988 dollars).

EVALUATION OF THE FORECASTS

While a forecast of a new product's sales is subject to a high degree of uncertainty, there is reason to believe that these analyses overstate how rapidly the market will actually grow. CBO makes no attempt, however, to provide an alternative forecast. This section discusses first the assumptions common to all forecasts, and then the methods and assumptions unique to the different studies.

Assumptions Common to All Reports

The forecasts share two critical assumptions--that HDTV will be a success with consumers, and that the market will grow rapidly from the outset. None of the forecasts has a scenario for true failure, even though such products are frequently launched. Many, if not most, new consumer products are not major successes; the video phone and the ultrasound shower, for example, were forecast to be mass consumer products.[11] Many products fail outright, while others take decades to become a major commercial success. Some fail as a result of bad design or marketing, while others fail because of demographic or other factors. In all but the Darby low-growth scenario, however, HDTV receivers are forecast not only to be successes, but to be one of the most successful consumer electronic products of the last several decades. The timing of HDTV's success is also an issue. Considering the differences between HDTV and other successful consumer products--for instance, the VCR is a complement to color television, while the HDTV receiver is a substitute--using their history of success as a pattern for HDTV's market growth may be misleading.

Will Consumers Buy HDTV? The forecasts assume that consumers will prefer HDTV to conventional television. The actual evidence in this regard is mixed, and should temper the forecasts' optimism.

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10. Calculated from Electronic Industries Association, Electronic Market Data Book: 1988, various pages.

11. One analysis of new product successes and failures suggests that overly optimistic forecasts for new technology products outnumber accurate ones by between 4 and 7 to 1. See Steven P. Schnaars, Megamistakes: Forecasting and the Myth of Rapid Technological Change (New York: The Free Press, 1989).

A study by the Massachusetts Institute of Technology (MIT), for example, gauged consumer reaction to HDTV in side-by-side comparisons with conventional color television sets. The study found that almost two-thirds of viewers preferred the HDTV sets over conventional sets, but that viewer preference was highly conditional and sensitive to such factors as program content and how close viewers were to the screen.[12] In one instance, 89 percent of viewers watching football footage preferred the conventional color set over the HDTV set when seated about 10 feet (the average home viewing distance) from 18-inch sets (the average size of home television tubes).[13] In another instance, when seated 3 feet (the ideal distance for viewing HDTV) in front of a larger (28-inch) monitor, 95 percent of viewers preferred watching the opening pageantry of the 1984 Olympics on the HDTV receiver rather than on the conventional color receiver. These strong swings in viewer preference in response to screen size, viewing distance, program content, and even color tone serve to reinforce the study's conclusion that "the preference for HDTV...is highly conditional and context dependent."[14]

Since the side-by-side comparison yielded a preference for HDTV, but not a dramatic one, the MIT study questions the claims that HDTV is a technology as revolutionary as color TV was in the 1950s. These doubts undermine the basic assumption that HDTV market growth will resemble the enthusiastic consumer response to color TV. Instead, the MIT study suggests, HDTV may replace mainly large-screen televisions--the so-called premium end of the television market.

The evidence regarding the growth of the premium end of the television market is mixed. On the one hand, analysts such as those at EIA and AEA point to the growing market share of large-screen tabletop television receivers. Television receivers with tubes 19 inches and under represented virtually all sales of tabletop and portable television receivers in 1980, but this share has dropped substantially in recent years and the share of larger-screen television receivers--those with tubes 25 inches and over--has increased quite rapidly. But this growth in market share has come largely at the expense of console television sets, whose share of the market dropped in half during this period. In addition, receivers with larger tubes were not widely available until recently. In fact, the premium end of the television market, defined as the sum of console sales and the sales of tabletop and portable receivers in the largest size category of television tube, has remained constant at roughly one-

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12. W. Russell Neuman, "The Mass Audience Looks at HDTV: An Early Experiment" (paper presented at the National Association of Broadcasters' Annual Convention, Las Vegas, Nevada, April 11, 1988). Neuman is an Associate Professor, Audience Research Group, Advanced Television Research Project, The Media Laboratory, Massachusetts Institute of Technology.

13. According to the MIT Media Laboratory, there were some technical problems with the conventional color tape of the football game, which lowered the amount of detail available but increased the contrast. Since the level of contrast on television is lower than both nature and cinema, the unusual availability of contrast may have influenced viewers' decisions.

14. Neuman, "The Mass Audience Looks at HDTV," p. 6.

quarter of all television sales during the 1980s.[15] Finally, the market for very expensive television receivers in the United States is quite small. According to rough estimates provided by EIA's Marketing Services Department, the sales of television receivers with a retail value over $2,000 approach 250,000 units per year, roughly 1 percent of all television sales.

Growth in the premium television market, however, should not be equated with the guaranteed success of HDTV. As noted elsewhere, there are several types of advanced television as well as several premium versions of current television technology. The forecasts offer no reason why one specific technology--HDTV--is the logical successor to the current market leader, even if consumers ultimately accept some form of advanced television. In fact, EIA makes the implausible assumption that sales of any one type of advanced television are unrelated to sales of the other types. HDTV may have more advanced technology than improved-definition television (IDTV) and enhanced-definition television (EDTV), but in the absence of clear signals from consumers, no inferences about its likelihood of success relative to the others are reliable.

The history of television purchases makes it clear that consumers have paid substantial amounts for what they perceived as progress. However, the VCR market has also shown that technical superiority does not necessarily guarantee market success. The major VCR market share, for example, was won not by the company that had the best picture--the BETA format pioneered by Sony was widely regarded as superior--but rather by other factors, such as playing time and price, which favored the VHS format.[16] The issue is whether consumers perceive HDTV as a sufficient refinement over standard color or improved television to warrant the additional expense. Judging from the price differentials forecast by AEA, the price advantages of the older technology may be substantial, especially in the early years when HDTV will cost between $1,500 and $2,300 more than standard color television sets.

How Fast Will HDTV Develop? Another assumption common to all forecasts is that HDTV manufacturers are going to "get it right"--that is, produce the exact product consumers want--the first time. This assumption is questionable. In the case of the video recorder, 10 years of unsuccessful consumer-oriented video recorders preceded the introduction of the model that became an "overnight success."[17] The features that have made today's VCRs so popular were not apparent or even possible in the period when firms first decided to develop a consumer video recorder. Indeed, consumers have probably been doing some learning also, discovering what they really desire. For example, the ubiquitous personal audio cassette player is an

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15. Data supplied by EIA Marketing Services Department. The categories of the tube sizes shifted each year. In 1980, the largest category was 20 inches and over, while in 1988 the largest category was 28 inches and over.

16. James Lardner, Fast Forward: Hollywood, the Japanese, and the VCR Wars (New York: New American Library, 1988), pp. 151-162.

17. Richard S. Rosenbloom and Michael A. Cusumano, "Technological Pioneering and Competitive Advantage: The Birth of the VCR Industry," California Management Review (Summer 1987), pp. 51-76.

obvious case of consumers not realizing they had a need until they actually saw the product. Similarly, the microwave oven languished for 20 years after its introduction until costs finally declined and families with two working parents found that they needed a way of preparing food rapidly.[18]

One issue that is particularly relevant to the timing of consumer purchases of HDTV is the availability of programming specifically for HDTV receivers. Color television sales, for example, did not really increase until color broadcasting became widespread. The investment decisions made by producers of television programs and other "software" that may be available for HDTV will be critical to consumers' desire to purchase the new sets, and vice versa. Any delay in programming availability, or a perception by consumers that HDTV programming is not substantially different from current programming, would probably also delay consumer interest in switching to HDTV.

The implication of these product histories and associated investment decisions about programming is that the commercial acceptance of HDTV may be a long time coming. There is no reason to assume that HDTV manufacturers will "get it right" the first time or that producers of television shows will decide to make their current production equipment obsolete by quickly shifting to HDTV production. Even if advanced television ultimately replaces the current color television system, that path may be more tortuous and may take much longer than the optimistic forecasts suggest. And, the final product may look very different from that envisioned by today's engineers.

Assumptions Specific to the Individual Reports

In addition to the common assumptions detailed above, each report makes specific statements or assumptions that deserve particular attention. These assumptions are examined below.

Darby Report. The Darby high-growth forecast assumes that HDTV receivers will be priced at roughly $600 during the early years of market penetration. But this assumption of such a low and constant price is neither realistic nor necessary for the growth of the HDTV market. As noted above, sales of color television receivers in the mid-1960s grew almost tenfold while the price was well above $1,000 in 1988 dollars. Furthermore, the forecast is not consistent with the type of price decline expected with the introduction of new consumer electronics. Unless the costs of electronic components decline at a much faster rate than is typical of new products, companies selling HDTV receivers priced at $600 may be selling them at a loss.

Electronic Industries Association. One potential problem with EIA's forecast of HDTV sales is that its underlying forecast of total television demand is questionable. It forecasts that the total demand for color television receivers in the year 2003 will be 40.2 million units, double the current level of 20.3 million units. CBO's initial statistical checks suggested, however, that this estimate may be high relative to

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18. Schnaars, Megamistakes: Forecasting and the Myth of Rapid Technological Change, p. 110.

demographic and economic variables forecast for the next two decades. While the 1988 sales level is in turn double the 1978 level, demand in the 1980s has been driven in part by such demographic factors as the economic maturation of the baby-boom generation. These demographic factors will not be as favorable over the next decade and a half. The U.S. television industry has also enjoyed a continuous consumer-led expansion since 1983. If overall economic growth in the future is less robust or is not led by purchases of consumer goods, the demand for television of all kinds may be depressed. On the other hand, the development of a large market for portable or small-screen televisions may increase television sales substantially.

American Electronics Association. The AEA forecast presents EDTV as becoming a very successful product, reaching annual sales of 1 million units within 3 years of introduction and 14 million units within 15 years; HDTV reaches a similar level within a similar time frame. It is questionable, however, that two advanced television technologies will be so successful within such a short time. Competing technological starts within the same medium can coexist (for example, Apple and IBM personal computers), but it is just as likely that one will edge out the other as occurred between BETA and VHS formats of VCRs, or, more broadly, between videotape and videodisc technology. Black and white and color TV sets were very successful in overlapping periods during the late 1950s and early 1960s, but after color sales exceeded 1 million units per year, monochrome television began a long decline.

The issues regarding the coexistence of various forms of advanced television are also related both to the number of ancillary investment decisions that have to be made and to the cost of serving the two markets. In BETA and VHS, the video rental stores (and consumers) wanted one standard in order to minimize their investment in any one movie, and their decisions probably helped speed the demise of BETA. Depending on the specific nature of the incompatibilities of EDTV and HDTV, most notably in their VCRs, the two technologies may or may not be able to coexist.[19]

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19. This analysis assumes that VCRs for all types of advanced television will be upwardly compatible--that is, an IDTV tape could be played on an HDTV set but not the reverse. This is currently the case with VHS and super VHS. Furthermore, there are no advantages to playing an IDTV tape on an HDTV VCR because the tape will not contain sufficient information for the receiver to create an HDTV image.

CHAPTER III

ECONOMIC EFFECTS OF HDTV ON RELATED INDUSTRIES

To many industry analysts, concern about the HDTV market is but one facet of a more general concern about the U.S. semiconductor industry and other U.S. electronics industries. These concerns are evidenced primarily by the broad range of effects that HDTV is claimed to have on other segments of the overall electronics sector, and by the degree to which the relatively small HDTV market (even under the most optimistic market forecast) is supposed to influence activities in much larger markets. In reviewing the claims for HDTV made in the market forecasts, CBO found, in general, that either the markets were unlikely to be big enough to have the desired effects, or the sequences of events asserted by the studies were not sufficiently developed to warrant the conclusions that were drawn.

The following sections analyze the specific claims of the three market forecasts for the effect HDTV might have on related products, particularly on products such as semiconductors that would become inputs into HDTVs. Supporters generally argue that HDTV sales could create an enormous demand for U.S.-manufactured inputs, and that U.S.-based firms would become more competitive as a result of supplying products to HDTV manufacturers. In most cases, CBO found that the ability of potential suppliers of semiconductors, flat-panel displays, and computers to compete in international markets would probably not be determined by the success or failure of the HDTV market. Rather, changes in U.S. market share in most of the supplier markets are more likely to result from the actions of firms and the development of technologies within those markets than from pressures or advantages created by HDTV.

CONCLUSIONS OF THE MARKET STUDIES

The market forecasts of the three studies are used to address two different, but related, economic questions:

- How would HDTV affect U.S. employment and output? and
- How would HDTV affect the competitiveness of the U.S. electronics sector?

The AEA report seeks to show how the presence of U.S.-based firms in a successful HDTV market would affect their ability to compete in the markets of other electronic goods. The EIA report attempts to determine how the U.S. economy--value added and employment, in particular--would be affected by a change in the combination of products that would result from a large HDTV market. The Darby report provides only illustrative statistics of HDTV's effect on domestic output

and employment and does not make specific predictions about the effects of HDTV on the competitiveness of the U.S. electronics sector. Moreover, Darby does not examine the consequences of the low-growth scenario, in which HDTV becomes a niche product.

Competitiveness of U.S. Electronics Firms

In the AEA report, the HDTV market is valued not only for its contribution to overall employment and income but because, AEA argues, it is big enough to help U.S. electronics firms advance their technology and become competitive in other areas, and it involves the development of particular technologies that will serve as "technology drivers" for the rest of the sector. Implicit in the AEA analysis is some combination of economies of scale and learning curves that results in cost reductions as sales rise (even in related markets), and a network of common technologies and components that makes the knowledge gained in HDTV markets applicable throughout the electronics sector.

The AEA report assumes that the U.S. market shares in semiconductors, personal computers, and other electronics industries are directly related to the U.S. market share in the HDTV industry: the lower the U.S. share in the HDTV market, the lower will be its market share in these other industries.[20] It also assumes that if the U.S. participation in HDTV is just slightly smaller than the U.S. participation in conventional television is now--roughly 13 percent of the world market--U.S. semiconductor manufacturing firms could lose up to 50 percent of their world market share. Even if the U.S. market position in HDTV is more than double the current U.S. market position in conventional television, AEA assumes that U.S. semiconductor firms would lose 20 percent of their world market share. Only if U.S. firms capture at least 50 percent of the U.S. HDTV market can U.S. semiconductor firms be assured of retaining their current share of the world semiconductor market. The AEA forecast assumes similar, though sometimes smaller, declines in world market shares of U.S.-based producers of personal computers and automated manufacturing equipment, depending on the positions of U.S.-based firms in the U.S. HDTV market.

Contributions to U.S. Output and Employment

The EIA analysis argues that regardless of whether the firms that make the HDTV receivers are foreign- or domestic-based, the bulk of the economic effect--on employment and value added--will occur in the United States. Forecasting from current trends, the report states that over 90 percent of the HDTV receivers destined for the U.S. market will be produced in the United States and that roughly 85

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20. The ATV Task Force of the AEA made these assumptions about declining market share of U.S. firms based on the opinions of their panel of executives and engineers from the electronics industry.

percent of the value of those units will be of U.S. origin.[21] This domestic production would increase U.S. value added by $6.2 billion, relative to what it would have been if HDTV technology was not commercialized. This increase in U.S. output would raise employment by 130,000 in HDTV manufacturing, and would create an additional 103,000 jobs through secondary effects.[22] The Darby high-growth scenario presents a similar increase of 240,000 jobs.[23]

The EIA's rationale for the large effect on U.S. value added is based on the fact that almost all television sets with screens larger than 20 inches are manufactured in the United States, albeit predominantly by foreign-based firms.[24] Since the benefits of HDTV are best realized in larger sets, the U.S. HDTV market is likely to be dominated by larger sets and hence largely served by local manufacturing plants, regardless of ownership. Because they are fragile and bulky, large glass tubes are expensive to ship. Consequently, television manufacturers are increasingly locating their glass tube plants in the United States, even though the electronic components within the tubes are often imported. Furthermore, a more recent EIA-sponsored study found that, in 1987, the average domestic content of a color television receiver produced in the United States was 70 percent, and the share was over 80 percent for larger sets.[25]

HDTV AND THE COMPETITIVENESS OF THE ELECTRONICS SECTOR

As noted, the three reports discussed here use their forecasts of HDTV sales to generate additional predictions. They discuss the effect of HDTV on the output and employment of the U.S. economy. They also consider the effects of HDTV on the technology, competitiveness, and market shares of U.S.-based firms that manufacture electronic components and equipment.

The forecasts of output and employment in the electronics sector are derived from input-output analysis and industry rules of thumb, which have both advantages and limitations. Economists differ regarding the usefulness of these methods to

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21. The 85 percent domestic content assumes that 100 percent of the electronic components, other than the tube, are imported. All tubes are assumed to be of U.S. origin. Should U.S. electronic components such as proprietary microprocessors be incorporated, the U.S. content would rise. Conversely, foreign subassembly might reduce the U.S. content. See the EIA report, "Television Manufacturing in the United States: Economic Contributions--Past, Present, and Future," pp. 50 and 68.

22. EIA report, pp. 73-76.

23. Darby report, "Economic Potential of Advanced Television Products," p. 43.

24. EIA report, p. 1.

25. Electronic Industries Association, Consumer Electronics, HDTV and the Competitiveness of the U.S. Economy (Washington, D.C.: February 1, 1989), p. 37.

forecast changes in output and employment. They agree that in an economy at full employment--where most analysts feel the U.S. economy to be in 1989--gains in one sector can come only at the expense of losses in others. But they disagree both on the potential for overall economic gains if the economy is at less than full employment, and on the possible contributions to the economy that might occur from an accelerated shift of resources away from more stagnant sectors and toward more dynamic sectors. Rather than focus on speculative effects that are probably not unique to HDTV, this section examines the more tangible effects that HDTV manufacturing might have on the competitiveness of U.S.-based firms.

According to the rationale behind the AEA forecast, the technology developed to serve the HDTV receiver market will allow foreign firms that have this technology to use it to become dominant in other electronics markets, from personal computers to communications equipment to workstations. The advantages of the high-resolution displays and serving the massive home market for HDTV receivers overwhelms whatever technical advantages U.S.-based firms might have within these product categories. The loss of the electronic goods markets might also subsequently entail a loss of the markets for the components used in those goods, especially semiconductors.

This possible sequence of events is not only forecast by the AEA, but is widely believed within the electronics industry. In its report, however, the AEA does not show how advantages in one area (display or imaging technologies, for example) confer such overwhelming advantages to all other markets for electronic goods. In the one market it does discuss--personal computers--this foreign advantage in display technology results in a 50 percent decline in the world market share of U.S.-based producers. Thus, the technical advantage would have to be great, though AEA offers no evidence that such an advantage would occur. (The personal computer industry is discussed in more detail below.)

A market as small as that forecast for HDTV is not likely to affect substantially the U.S. market share in computers, communications equipment, and other electronic equipment. These markets are already large and continue to grow rapidly, and they will probably remain far more significant factors than HDTV in the evolution of electronics technology. While the AEA report forecasts a $28.5 billion world market for HDTV receivers and VCRs by 2010, other U.S. electronics industries are already much larger and are likely to continue to grow at a significant pace over the next two decades.[26] Taken together, the world electronic equipment sector grew by $54 billion in 1988 to reach $461 billion.[27] Thus, not only is this sector more than 15 times larger than the HDTV market, but also its annual growth is almost double that projected for the HDTV market.

While the effects of HDTV on the commercial development of the electronics sector may be quite limited, some analysts feel that consumer electronics as a whole

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26. AEA report, "High Definition Television (HDTV): Economic Analysis of Impact," pp. 2-4 and 2-6.

27. "1989 U.S. and Overseas Market Forecast: Looking for a Soft Landing After Hypergrowth," Electronics (January 1989), p. 54.

(of which HDTV would be a part) plays an important role in the creation and maintenance of a competitive electronics sector.[28] First, the consumer electronics market is sizable in its own right: about 3 out of every 10 integrated circuits manufactured worldwide go into consumer products, although, in the United States, the share of consumer electronics is only 15 percent.[29]

Second, there is a perception that Japanese electronics companies have used the consumer market to build up their capabilities and expertise in manufacturing semiconductors and other electronic goods. Although the technology used in consumer products is not as sophisticated as that used in other electronics markets, keeping cost down is much more important and, some argue, this ability to control costs carries over to other areas. In this regard, Japanese domination of the market for liquid crystal displays and charge-coupled devices--the light-sensitive integrated circuits that make camcorders work--is seen as having come from their strong position in the VCR, wristwatch, and other consumer markets. Similarly, surface-mounting technology, a lower-cost method of mounting components on printed circuit boards, first enjoyed widespread use in consumer electronics before being introduced into computers and other areas. On the other hand, the single largest market success of Japanese semiconductor companies--the computer memory market --has thus far had little to do with the consumer market: Japanese companies had to develop that expertise directly, by manufacturing memory devices for overseas markets. In addition, cost control is not as important in other markets: performance or some other factor is often of much greater importance than a small reduction in purchase price.

Policy discussions concerning the influence HDTV might have on the production of other electronic goods often center on semiconductors, personal computers, and flat-panel displays. These products are discussed below.

Semiconductors

The AEA forecast assumes that if U.S.-based firms fail to control a substantial portion of the HDTV market, U.S.-based semiconductor makers will be frozen out as suppliers to this market by the foreign HDTV producers. It also assumes that foreign producers of semiconductors selling into the HDTV market will gain vast experience and be able to reduce their costs, thus driving U.S. semiconductor makers out of even more markets. This scenario seems implausible in three main areas: the size of the demand for HDTV semiconductors, the ability of foreign semiconductor producers to transfer gains in one market into gains elsewhere, and the assumed behavior of U.S. HDTV makers.

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28. See Electronic Industries Association, Consumer Electronics, HDTV and the Competitiveness of the U.S. Economy.

29. Congressional Budget Office, The Benefits and Risks of Federal Funding for Sematech (September 1987), p. 19.

Demand for HDTV Semiconductors. The AEA estimates that the use of semiconductors in HDTV receivers worldwide will total $1.8 billion in 2010.[30] The same report projects a worldwide semiconductor market of $303 billion in 2010 (see Figure 4). Even after demand for HDTV has started to grow, semiconductors used in HDTV receivers will still represent less than 1 percent of AEA's forecast of total demand for semiconductors.

The AEA then argues that the difference between U.S. firms controlling 10 percent of U.S. HDTV sales and 50 percent of U.S. HDTV sales is the difference between realizing economies of scale or learning effects in the manufacture of semiconductors and not realizing these gains. Even assuming that U.S. firms buy only U.S. integrated circuits and foreign firms buy only foreign integrated circuits --an extreme assumption--the maximum difference between these two scenarios is $272 million. Thus, the AEA report assumes that the $272 million difference reduces U.S. production costs sufficiently to increase total U.S. semiconductor sales from $62 billion (20 percent of the world market) to $124 billion (40 percent of the world market). This assumption seems implausible. Even if the worldwide HDTV market is included, the learning effects or scale economies to be realized by additional sales of $735 million, or 0.2 percent, of semiconductors worldwide, are extremely unlikely to be that large.[31]

The AEA figures also suggest that television receivers sold in the United States, including HDTV, will use a declining share of semiconductors over the forecast period: in 1990, receivers sold in the United States will consume 1.4 percent of world semiconductor production, falling to just 0.4 percent in 2010. Even under AEA's forecast for worldwide HDTV sales, the HDTV market would account for less than 1 percent of semiconductor sales, assuming that foreign HDTV receivers have the same semiconductor content as U.S. HDTV receivers. And, in absolute terms, AEA's projections do not show that U.S. HDTV production will require significantly more semiconductors by 2010 than conventional color television will use in 1990: $682 million versus $664 million, respectively.

The AEA and others argue that, although the absolute size of the HDTV semiconductor market might be small, the integrated circuits required are so sophisticated that HDTV technology will drive engineering innovation. This seems

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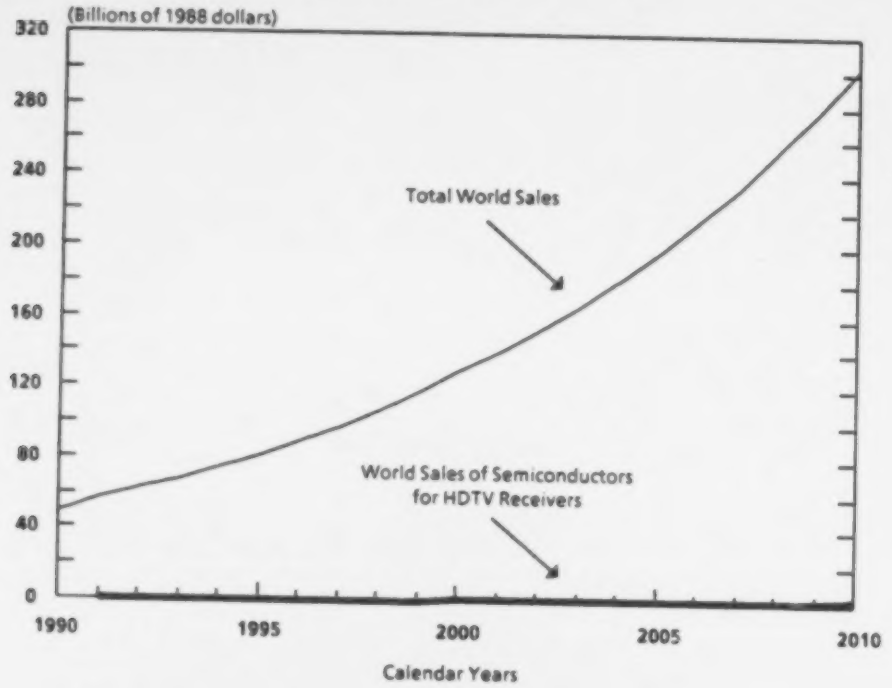
30. Calculated from the AEA report, pp. 2-3 and 2-10. Because AEA has no estimate for the use of semiconductors in the HDTV VCRs, this estimate understates the complete value of semiconductors used in HDTV. This and other forecasts suggest that between 6 percent and 12 percent of HDTV retail value is attributable to semiconductor costs. For data on the semiconductor content of HDTV, see the AEA report, pp. 2-4 and 2-10; and the EIA report, p. 50.

31. The figure of $735 million is derived by dividing $272 million (the assumed loss within the U.S. market) by 37 percent (the U.S. share of the world HDTV market). This calculation assumes that all HDTV receivers worldwide have the same semiconductor content and that U.S.-based firms are going from a 10 percent to a 50 percent share of the worldwide HDTV market.

Figure 4.
AEA Forecast of World Sales of Semiconductors



SOURCE: Congressional Budget Office using data from American Electronics Association, "High Definition Television (HDTV): Economic Analysis of Impact" (prepared by the ATV Task Force Economic Impact Team of the AEA, Santa Clara, Calif., November 1988).

NOTES: Assumes that semiconductor content of non-U.S. HDTV receivers is the same as that of U.S. receivers. Excludes HDTV video cassette recorders.

highly unlikely for the following reasons. First, the U.S. semiconductor industry spends over $2 billion each year in R&D, and federal agencies spend another $500 million, independent of HDTV.[32] The level of HDTV R&D specifically devoted to integrated circuit R&D is likely to be much lower than this. Assuming that all R&D is equally productive, most semiconductor engineering innovations are more likely to come from the semiconductor R&D already in place than from marginal HDTV R&D programs. Second, neither the memory devices nor the digital signal processors--the most common types of integrated circuit used in HDTV--are more sophisticated than those currently produced by the semiconductor industry. U.S. makers of integrated circuits already produce microprocessors with 1.2 million transistors each.[33] Finally, U.S. semiconductor manufacturers have traditionally led in design innovation while exhibiting weakness in manufacturing ability. This lead in design innovation is long-standing and cuts across many product categories. It seems unlikely that one program could reverse this long-standing advantage.

Although it is unlikely that HDTV receivers will drive semiconductor technology in the aggregate, they may do so for specific integrated circuit submarkets. Digital television receivers are voracious consumers of digital signal processors. Estimates suggest that this market is currently in the $500 million range, of which U.S.-based firms produce $300 million.[34] While the consumer portion of that market is only 5 percent to 6 percent of the total, it is growing. Thus far, however, firms with expertise in producing digital signal processors for consumer markets have not had much success in penetrating other portions of the digital signal processor market. To be made cheaply, consumer digital signal processors have to be simple and dedicated. Hence, they have very little software and little peripheral support. Whether HDTV would represent a sufficiently large market to overcome this limitation is not clear.

Transferring Market Gains. The AEA data on market share also assume that all semiconductors are the same and that improvements in the manufacturing process are immediately transferred from one type of device to the other. In fact, integrated circuits serve many different purposes, and advances in one market do not immediately transfer to another. For example, Intel Corporation makes the microprocessors for IBM-compatible personal computers. Intel owns the property rights to those designs, and advances in memory technology alone will not permit another firm to produce those integrated circuits. If anything, the trend in personal computers (and other electronic devices) is to increase the use of integrated circuits with proprietary designs while decreasing the share of devices whose design is nonproprietary. The increasing use of application-specific integrated circuits is one concrete example of this trend. If this trend continues, then the markets are likely to become increasingly compartmentalized because of particular design expertise,

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32. Congressional Budget Office, The Benefits and Risks of Federal Funding for Sematech, p. 43.

33. Jonah McLeod, "They're Faster, They're Denser, and They're Here: 80486 and 68040 Debut," Electronics (April 1989), pp. 27-28.

34. Jonah McLeod, "32-Bit Floating Point: The Birth Pangs of a New Generation," Electronics (April 1989), p. 72.

making the wholesale decline in U.S. semiconductor industry even less likely. But this compartmentalization also means that the mass market effects would be less likely to revitalize the industry. The various semiconductor markets are not completely isolated from each other. Rather, each market has its own internal logic and dynamism, and gains in one market translate into gains in other markets only as this logic and dynamism allow.

Behavior of U.S. and Foreign HDTV Producers. There is little reason to believe that HDTV components, other than the picture tube and cabinetry, will necessarily be manufactured in the United States. During the 1980s, U.S. personal computer companies experienced the type of growth that HDTV advocates hope for. Yet during that time, all but three U.S. semiconductor manufacturers stopped making dynamic random access memories (DRAMs)--a principal component for the personal computer. Furthermore, U.S. manufacturers of personal computers seemed as willing to buy Japanese and Korean DRAMs as U.S. integrated circuits. One would assume that U.S. HDTV manufacturing firms would also buy foreign integrated circuits. If HDTV causes a substantial expansion in demand for DRAMs, this additional demand is most likely to go to firms that already manufacture them.

The assumption that U.S.-based semiconductor producers will be excluded from the HDTV market if U.S.-based firms are not manufacturing receivers also ignores the recent performance of U.S. semiconductor companies. One of the leading firms in producing advanced digital integrated circuits for conventional color receivers is a U.S. firm, ITT Semiconductors. In fact, it enjoys a substantial market share in Europe, where there are no U.S. producers of television receivers. This firm has already announced its intention of producing integrated circuits for HDTV receivers, regardless of where those receivers are made.

Given the experience in the DRAM markets in the mid-1980s, however, U.S. semiconductor manufacturing firms and federal agencies responsible for trade are unlikely to allow U.S. component makers to be removed from the component businesses in which they now have substantial presence. Even though most of the problems for U.S. makers of integrated circuits during the 1984-1986 semiconductor slowdown were the result of declines in demand for semiconductors rather than the result of an increase in foreign market share, U.S. policy is currently much more sensitive to potential technology losses.[35] Furthermore, some U.S.-based semiconductor producers and users have started to form a consortium to produce DRAMs in the United States. This move indicates a greater awareness on the part of semiconductor consumers regarding the desirability of having domestic sources of semiconductors.

Flat-Panel Displays

The other component technology frequently mentioned in connection with HDTV is the flat-panel display. The three forecasts generally assumed that cathode ray tubes would be used for most HDTV receivers; flat-screen displays are currently

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35. Congressional Budget Office, The Benefits and Risks of Federal Funding for Sematech, pp. 15-16.

much smaller and much more expensive than tubes.[36] But HDTV engineers want ultimately to make the receiver displays using flat screens, which would then permit consumers to fit large receivers into their homes. Since the visual difference between HDTV and conventional color television is more noticeable with larger screens, HDTV advocates argue that flat-screen television will create both the demand and the opportunity for the HDTV market to grow. In addition, since the large-screen segment of the television market is growing, linking HDTV to a large-screen technology should improve its chances of success. The Japanese government, in conjunction with several large electronics firms, has begun a $75 million joint research effort to develop large flat-panel displays for possible use in HDTV. This highly publicized, multiyear effort has further spurred concern that U.S.-based firms will find themselves at a technological disadvantage in this market unless they initiate a similarly large research effort.

While the development of flat television receivers has been long awaited, they are just now becoming feasible. Even so, despite the Japanese research effort and new DARPA funding, success is not guaranteed, as major technological and economic hurdles must be overcome. For instance, with liquid crystal displays--the kind most commonly used for flat panels--the display panel is essentially a large integrated circuit: a 12-inch screen is a 12-inch circuit. In addition, manufacturing a liquid crystal HDTV screen is the equivalent of making an integrated circuit that has 1.6 million transistors, which is as many components as the most sophisticated integrated circuits currently have. The fabrication of such massive integrated circuits at reasonable cost will be a technological challenge.[37]

If flat-screen color television becomes a reality, it will be a major step forward in consumer electronics and could affect other parts of the electronics sector. Last year, nearly 750,000 laptop computers were sold in the United States, most at premium prices. Most of these had some form of flat screen. The screens for color television need to be better in several ways than the screens for personal computers. Television receivers need full-motion video, while, outside of engineering workstations, computer monitors do not need this level of quality. Consequently, any firm that masters the technology sufficiently to produce flat-color television receivers will be well positioned in the market for flat-panel computer monitors.

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36. Only the AEA assumed that flat screens would account for a sizable segment of the market, and they assumed it would be at the premium end of the HDTV market. Their forecast assumes that sometime in the next 5 to 10 years, relatively small expensive panels of HDTV quality will appear, but that these panels will become large and less expensive over the succeeding period.

37. Rather than being a fraction of an inch square, a flat-panel display would be much larger, increasing the opportunities for flaws in the materials and errors in manufacturing. Since part of the success in making integrated circuits more dense and more cheaply has come from reducing their size, conventional processing techniques will be unusable. See Samuel Weber, "It's a New Age for LDCs," Electronics (May 1989), pp. 96-100.

But, if quality flat-panel displays can be made at reasonable costs, they will come into widespread use whether HDTV becomes a reality or not. They could be used as substitutes for television tubes of any format: conventional color television or any of the three advanced television formats. In fact, small conventional television receivers that use flat-panel displays are now available commercially. If flat-panel displays of the right size and cost become available, they may appear first in non-HDTV formats, particularly if HDTV technology is delayed. In addition, the use of flat-panel displays in computers is growing independently of developments in HDTV. On the other hand, if HDTV and flat-panel television succeed as a joint product, then the EIA forecast of domestic content, which is predicated on U.S. production of large picture tubes, may prove incorrect because flat panels may be easier to import than the more fragile picture tubes.

The United States, however, already imports many, if not most, of its computer monitors. According to the Department of Commerce, 8.9 million monitors, worth a total of $1.9 billion, were imported in 1988. South Korea and Taiwan together provided almost half of the total. Thus, even if flat-panel displays become much more widely accepted for use in computers, they may largely substitute for terminals the United States currently imports. In addition, the presence of so many low-cost substitutes means that Japanese producers of flat-panel displays may be unable to charge very high prices for their devices outside of specialized markets, such as the laptop computer. On the other hand, many in the U.S. industry worry about the long-term implications of relying too heavily on Japanese competitors for an input as crucial as the display, especially if it eventually supplants the cathode ray tube.

Personal Computers

The AEA report assumes that HDTV technology will be the difference between the U.S. personal computer industry holding its current world market share (70 percent) or declining to half that level. They argue that without the incentive of HDTV technology, U.S. personal computer technology will fall behind and foreign competitors will thereby increase their market share.[38]

How realistic is this scenario? Foreign competitors may or may not increase their share of the U.S. personal computer market, but U.S. firms already have every incentive to perform R&D and improve their manufacturing processes. The U.S. personal computer market was $23 billion in 1988, according to industry figures.[39]

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38. AEA further assumes that the U.S. market share in personal computers could be cut in half by 1990--a date when its forecast suggests a total U.S. HDTV market of only 1,000 sets--unless the federal government and U.S. manufacturing firms aggressively pursue HDTV.

39. International Data Corporation, cited in Karen Blumenthal and Robert Tomsho, "An IBM Tagalong Sets Independent Course, with Plenty of Risks," Wall Street Journal, April 21, 1989, p. A1.

The U.S. IBM-compatible market alone was roughly 7 million machines in 1988.[40] By contrast, according to AEA's estimates, the U.S. HDTV market is not expected to reach that level until after 2007. Furthermore, AEA's sales projection assumes that HDTV prices will be well below $1,000 per machine, whereas the average price of the IBM-compatible personal computer is well above that. Thus, the assumption that U.S. personal computer technology will be driven by HDTV technology requires that U.S. personal computer manufacturing firms place more emphasis on a small market that may or may not exist in 2007, and less emphasis on a $23 billion market that exists today. Common sense and economic theory indicate the opposite.

Research and development for HDTV might be producing new designs and advances, but the U.S. computer industry is not standing still. According to the National Science Foundation, U.S. computer makers spent $8.5 billion of their own funds on R&D in 1987 alone. While not all or even most of this money was for personal computers, it indicates the level of funds available to advance related technology. Thus, unless HDTV R&D is especially productive, the major advances in computer technology will most likely come from within the industry.

Although HDTV receivers can be viewed as dedicated computers, they will not be able to run conventional software unless they are substantially modified. Most people buy personal computers because of the software. The hardware may make the software run faster or better, but the software--word processing, spreadsheets, desktop publishing--is ultimately what determines the use of the computer. Given the existing base of software--$15 billion for the IBM-compatible personal computers alone--one would assume that most computer users would not leave their existing computers just because better displays were available on HDTV receivers. If, on the other hand, HDTV receivers incorporated personal computers that are compatible with existing software, their complexity (and cost) would be much higher, and they would be at a competitive disadvantage in both the receiver and the personal computer markets.

When focusing on the computer market, analysts sometimes forget that the market for computer peripherals, such as printers, is also large and that the devices are complex. Many of these peripherals are almost as complex as the HDTV is forecast to be, and their markets are as large as the near-term forecast for HDTV. Some of the devices now thought of as printers are, in fact, small computers. For example, the popular laser printer has a microprocessor and almost as much memory (and more can be added) as most personal computers. As semiconductor costs decline, other computer peripherals might increase in popularity. The optical scanner, for example, is waiting for cost reductions to move into the mass market. With the right software and enough memory, the scanner may be able to read magazine articles and other printed matter directly into a computer and store it in machine-readable form for later use.[41] The current optical scanner market for

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40. Michael Alexander, "Users Calm About Clone Battle," ComputerWorld, March 27, 1989, p. 43.

41. Roberta Furger, "A Technology Comes of Age," Infoworld, June 12, 1989, pp. 47-51. One type of scanner--an optical character reader--needs an average of 4 megabytes of memory, exactly the size projected for an HDTV receiver.

computers is over $800 million per year, a figure that AEA's combined market for HDTV receivers and VCRs is not forecast to reach for another decade.[42]

One technology thrust in computers, which runs parallel to but is independent from HDTV, is the development of higher-resolution displays. Computer-aided design and engineering often need high-density displays.[43] Makers of IBM-compatible computers already offer graphics systems with the same number of lines currently planned for HDTV.[44] Throughout the electronics sector, increased use of digital imaging systems as parts of larger electronic systems is widely discussed. It is quite likely, therefore, that a portion of the computer market will soon be using display systems that resemble HDTV displays. Because of this similarity, there might be some transfer of technology between the high-resolution display and HDTV. But the dynamics of that market are quite different from those of the consumer market on which these three reports focus. For one thing, these uses will largely be determined by software: unless the design software is available, the users are not likely to demand a specific hardware system. In addition, these premium displays are usually purchased as part of an equipment system and so are only one factor in the decision to purchase the whole system. In any event, these uses will initially be of interest to a limited segment of the market.

CONCLUSIONS

This report has examined three forecasts of the potential HDTV market and analyzed them to answer two questions: (1) Will there be a large market for HDTV receivers? and (2) Is this market critical to the competitiveness of the U.S. electronics sector? The forecasts are very optimistic with regard to market size and certainly with regard to timing, although some consumer electronics products have enjoyed the level of success they project.

Evaluation of forecasts of HDTV's effect on other electronics markets seems clearer. Even the optimistic forecasts of the HDTV market are small relative to the other electronics markets. Thus, it is unlikely that HDTV will by itself revitalize the U.S. electronics sector.

These conclusions do not necessarily mean that federal support for HDTV development is without merit. Some might support HDTV for reasons other than competitiveness in the electronics sector--for instance, employment, national prestige or scientific advancement. The Department of Defense has a long history of pursuing display technologies that have possible military uses. In addition, HDTV development, although small on its own, might have a role to play in a broader strategy for the U.S. electronics sector.

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42. "The PC Juggernaut Bogs Down," Electronics (January 1989), p. 59.

43. Tom Manuel, "PC Graphics," Electronics (April 1989), pp. 84-88.

44. Bob Ponting, "Beyond VGA," Infoworld, June 26, 1989, pp. 45-49.